result of this gorge traffic was suspended on the Juniata highway bridge which crosses the Juniata River near its mouth to Duncans Island, and also on the covered highway bridge at Clarks Ferry, which spans the Susquehanna from Duncans Island to the eastern shore. The Chemung ice broke at Corning about 3 a. m. of the 13th and moved slowly down the river, forming ice jams, which broke as the water accumulated behind them, re-formed and broke again. Frank Gray and two boys who were with him narrowly escaped drowning, being caught by the ice flood on the flats between Lowman and Wellsburg while driving a team. They were finally rescued by men in boats. The horses also were saved. This ice flood reached Towanda on the night of the 13th, the ice breaking there about 9 p. m. of that day and moving out on a stage of about 13 feet. It reached Wilkes-Barre on the night of the 14th, passing on a stage of about 18 feet. The flood water from the Juniata gradually lifted the ice in the Susquehanna River below Duncannon, the break at Harrisburg occurring at 3:15 a. m. of the 15th on a stage of about 11 feet. The ice from the Chemung River and the North Branch below Athens reached the main river early on the morning of the 16th and began to pass Harrisburg about 3 p. m. of that date, the river reaching a maximum stage of 15.2 feet at 6 p. m. This flood lifted the gorge at the mouth of the Juniata and all the ice from the Juniata, Chemung, and the North Branch, together with most of that in the main river below Sunbury, lodged at Pequea, a short distance below the mouth of Conestoga Creek, about 55 miles below Harrisburg, forming a great gorge said to have been 20 or more feet in thickness and several miles long. This gorge caused serious flooding at Safe Harbor and vicinity, the railroad tracks there being several feet under water and ice for three or four days.

The ice in the West Branch broke at Clearfield at 1 p. m. on February 13, the river there reaching a maximum stage of 9.4 feet, slightly above flood point. At Renovo the break occurred about 4:30 p. m. of the 13th. The ice continued to move slowly, piling up and breaking and finally lodging, jamming the channel from Jersey Shore almost to Lock Haven with a gorge said to range in thickness from 10 to about 20 feet. Following a short period of warm weather with rain on the 19th and 20th, the water rose behind the gorge at Jersey Shore, causing serious flooding at points above, particularly at Lock Haven, where the water reached a stage of about 21 feet, flooding the railroad tracks to a depth of several feet and causing the suspension of all trains on the Northern Central and New York Central Railroads. The water covered most of the town to a depth of several feet. Some houses in the lower part of the city had water almost to the second floor. A cold wave with zero temperature on the night of the 20th caused the water in the houses to freeze to a thickness sufficient to permit people to skate on it. The light plant was flooded, and the people were without light and in many cases without fuel. The mayor of Lock Haven appealed for help, which was speedily furnished, but much suffering and some sickness resulted and the damage to property was great. The lower part of the Jersey Shore gorge broke on the night of February 20, passing Williamsport on a stage of 21.4 feet, 1.4 feet above the flood point. This break did not immediately relieve the serious situation at Lock Haven, as the upper part of the gorge held until about 3.30 p. m. of the 21st. During the 15 minutes following this break the water fell 4 feet on the Lock Haven gage. The ice from the West Branch began to pass Harrisburg during the afternoon of the 21st, the river reaching a maximum stage of 14.1 feet at 3 a. m. of the 22d and remaining stationary until afternoon, when it began to fall slowly. This flood opened a channel on the west side of the river at Pequea, and the river there fell rapidly on the 22d. Probably many small gorges or jams formed of which no information was received. The greatest damage to property occurred behind the Jersey Shore gorge, principally at Lock Haven, where it probably amounted to $100,000. Many highway bridges were damaged and a few were destroyed, and some railway bridges were damaged. The Pennsylvania Railroad bridge crossing Conestoga Creek near Pequea sank about 2 feet while a freight train was crossing it soon after the gorge broke.

An accurate estimate of the damage caused by ice floods is impossible, but it is believed it is conservative to say that the loss in the Susquehanna watershed was at least $300,000.

Considering the great accumulation of snow and the thickness of ice on the streams the damage was much less than might have been reasonably expected under the circumstances. A general and heavy rain over the watershed with high temperatures would have caused a disastrous flood. Actually but few places suffered, and the waters reached flood stage only over comparatively short stretches.—*E. R. Demain, Meteorologist in Charge.*

DELAWARE AND SCHUYLKILL RIVERS.

Philadelphia, Pa., river district.

Early in February, 1918, there was a snow covering of about 30 inches over the headwaters of all of the streams. The snow was solid and held a large water content, being the accumulations of the December and January snows.

It so happened that the snow melted a little at a time in three or four periods, and without rains of consequence; so that the ice, which was the heaviest in many years, broke up and passed out with comparatively little obstruction and with no material damage. Jams were reported in the Lehigh River at the Parryville dam and at Treichler's, but neither was of a serious character. A large amount of ice backed up in the Schuylkill at Philadelphia, but passed out on a sudden rise and without damage. The East Branch of the Delaware at Fishs Eddy, N. Y., rose to 16 feet on the 20th (the flood stage being 10 feet), but the water and the ice passed out with only slight damage. At Hale Eddy, N. Y., on the West Branch of the Delaware, the water rose to 13.4 feet on the 20th (flood stage being 12 feet). These waters seemed to spread out farther down the river, and at Port Jervis the highest stage was 9 feet (flood stage being 18 feet), while at Phillipsburg (junction of the Delaware and Lehigh) there was a stage of 15 feet on the 21st, or 7 feet below the flood stage.

The Schuylkill rose high enough at Manyunk, Philadelphia, on the 21st to temporarily suspend operations in several mills. Warnings were given to the police department on the 20th and movable property was taken care of. These were the only warnings issued and were the only ones practicable.—*George S. Bliss, Meteorologist in Charge.*

POTOMAC RIVER.

A short spell of mild temperature with light rain on February 10 melted much of the snow in the watershed above Washington, D. C. Mild temperature on the 11th and 12th, without rain, caused a break-up in the ice on the 12th from Cumberland, Md., to below Harpers Ferry, W. Va.

Washington, D. C.

February 13, 1918.—Ice broke up at 2:00 a. m. and a gorge formed from Chain Bridge nearly to the Aqueduct Bridge, gorged from Rock Creek to Highway Bridge; water 6 feet above bank at Chain Bridge and ice left 6 feet deep from river to canal bank. Gorges broke in places during the day and reformed at night. A firm gorge formed against Acqueduct Bridge during the night of February 13–14 and extended to Highway Bridge on the District of Columbia side. The old channel on the Virginia side of Analostan Island cleared about 5.00 a. m. and allowed the flow of the river to go by that channel. Before the old channel on the Virginia side cleared, the ice was piled up 3 to 4 feet above the river wall at the gage, Twenty-seventh and G Streets, and would probably have gone 5 feet higher if the Virginia channel had not cleared. The water was 3.5 feet deep on K Street and Thirty-first Street, but stores were not flooded below Eighth and Pennsylvania Avenue.

February 16, 1918.—Some small gorges still held between Chain Bridge and Aqueduct Bridge.

February 18, 1918.—Channel on District of Columbia side cleared from Acqueduct Bridge to Highway Bridge. All house boats on the river were crushed by the ice and all boat houses, except three, were practically destroyed. Many dredges were carried down the river, but most of these were recovered later.

Loss to house-boats estimated at $1,500.

Loss to boathouses estimated at $15,000.

Loss to barges, stores, and business houses on K Street estimated at $38,200.—*A. J. Henry, Meteorologist in Charge.*

JAMES RIVER.

Richmond, Va., river district.

The winter of 1917–18 to date has been unusually severe. Temperatures low enough to form ice on the various rivers of the State, were general in the latter part of November and from that time on until early in February, they continued low. In the river district under the supervision of this office (James River) the ice steadily increased in thickness during December, 1917, the coldest month of that name of record in this State, and also through January, 1918, and it was not until January 26, 1918, that the day temperatures became high enough to cause melting of the ice.

On this date, also, a six-day period of precipitation, which came partly as rain and partly as snow or sleet, set in. Fortunately, however, the night temperatures during this period were at freezing, or below, and this checked the run-off and prevented any sudden rise in the river and breaking up and gorging of the ice. From the close of January to February 6 freezing weather kept the ice intact, but on the last-named date the day temperatures rose and a general and decided thaw set in, checked as before by cool nights. The snow cover in the watershed, which was practically continuous from the middle of December until this time, and unusually heavy, disappeared rapidly and the resulting run-off soon reached the James, lifting the ice and starting it downstream. The situation thus became full of danger and was a source of anxiety to this office, and the people of the cities and

towns along the river bank. Ice gorges formed on February 8 at Indian Rock and Sabot; on the 9th at Glasgow; and on the 10th at Colemans Falls and Hatton, with ice reported to be from 18 inches to 2½ feet thick, which piled up at some points to a height of 6 feet or more above the water. A continued though slow rise in the river broke these gorges on the last-named date and they moved downstream to tidewater, being further broken in this passage over various shoals and rapids. These fields of broken ice passed by Richmond for several days prior to February 12, when the river was clear here, but they lodged again at Dutch Gap, about 25 miles below this city, and interrupted navigation on the 12th.—*E. A. Evans, Meteorologist in Charge.*

SUMMARY.

The essential facts established by the foregoing reports are as follows: A period of excessively cold weather set in in December, 1917, and continued without important moderation until about the first of February, 1918. The extreme minima for the time and place during a period of almost half a century were reached in localities throughout the Ohio Valley. It is probable that a low minimum temperature is not so effective in causing ice formation as consecutive nights of temperatures below a certain value which may be called the critical minimum. In the vicinity of Washington, D. C., a minimum temperature of 20° F., in a thermometer shelter, on three consecutive nights will cause ice several inches in thickness to form in streams of running water. The mean minimum temperature at Cincinnati, Ohio, December, 1917, was 13.9° F.; January, 1918, 8.3° F.

As a result of this long period of low temperature the ice in the pools along the streams attained great thickness and continued firm throughout the cold period. The gorged ice likewise became solidified and capable of great resistance to pressure from upstream. The break-up began on the southern tributaries of the Ohio as the direct result of moderate rains, separated by an interval of but 24 hours. The temperature at the time of the rain was not greatly above the freezing point, and it remained above freezing but a short time; consequently there was no opportunity for the ice to become soft and honeycombed. As a result the ice which passed into the Ohio from southern tributaries, and that which broke up in the main stream, was unusually firm and in great cakes. Some idea of the size of the cakes may be had from fig. 7.

The northern tributaries of the Ohio remained firm during the critical period and contributed very little water to the trunk stream.

The ice in the trunk stream broke up in sections and on moderately low stages. It is probable that the low stages and the reduced velocity of the current was a factor in conserving the size of the ice blocks and in preventing a material reduction in the ice floes by attrition.

The loss, including suspension of business, due to the breaking up and passing out of the ice, summarized by districts, follows:

Pittsburgh, Pa.	$300,000
Parkersburg, W. Va.	9,600
Cincinnati, Ohio	1,988,000
Louisville, Ky.	365,000
Evansville, Ind.	127,905
Cairo, Ill.	421,700
Total for the Ohio	3,212,205

It seems to have been the almost universal experience along the river, that the winter mooring places of river craft were unsafe when the break-up in the ice came. The only exception was at Louisville, Ky., where it is reported that craft totaling $1,000,000 in value found safety in the Portland Canal.

The loss on the Mississippi due to ice gorges while not so heavy as in the lower Ohio was yet considerable. See report of S. C. Emery, of the Memphis, Tenn., district (p. 92).

The final break-up of ice in the northern tributaries of the Ohio and the Mississippi above St. Louis was accomplished without serious damage or loss due, it is believed, largely to the fact that the ice in those streams had become more or less honeycombed and soft by spells of thawing weather in February. At the close of that month the ice had not yet gone out of the Missouri above Omaha, Nebr., although its condition promised an early break-up. By March 11 the river was open to Sioux City, Iowa.

At the end of February the Mississippi was practically free of ice south of Davenport, Iowa. Ice at that place went out on March 2, and by March 12 the ice had broken up as far north as St. Paul, although the river at La Crosse, Wis., had not yet cleared.

The Hudson was free of ice at Albany and Troy, N. Y., also the lower Mohawk; but ice still held above Schenectady and in the lower Hudson. The upper reaches of New England streams were icebound at the close of the month.